WORLD RESOURCES INSTITUTE

TECHNICAL NOTE

UNIVERSAL MILL LIST: A STANDARDIZED METHODOLOGY FOR CREATING A GLOBAL DATABASE OF PALM OIL MILLS

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EXECUTIVE SUMMARY

The goal of this methodology is to provide guidelines for creating one global list of palm oil mills that can be used by all palm oil mill stakeholders, including oil palm producers, processors, and traders; consumer goods manufacturers; retailers; banks/investors; and environmental and social nongovernmental organizations. Palm oil mills are facilities that process fresh fruit bunches from oil palm trees, turning them into palm oil. One palm oil mill may process fruit from multiple oil palm plantations, and palm oil suppliers to large corporations may source from multiple palm oil mills, which can lead to multiple disaggregated datasets on palm oil mill names and locations. This dataset integrates publicly available mill information, including on mills that are certified through the Roundtable on Sustainable Palm Oil, one of the world's leading sustainable palm oil certifying bodies, as well as mills privately submitted by various companies. Key features of this dataset include robust verification of mills to determine accurate GPS locations, the best available data on mill names and parent companies, and unique IDs that can be used across platforms and companies. This methodology has thus far resulted in location and attribute information for over 1,800 palm oil mills globally.

INTRODUCTION

A growing number of companies in the palm oil industry have announced ambitious commitments to, among other goals, reduce or eliminate deforestation from their supply chains and make their supply chains more transparent. One of the major challenges facing these companies is

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Technical notes document the research or analytical methodology underpinning a publication, interactive application, or tool.

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tracing palm oil through large and complex supply chains back to its point of production to determine whether forests have been cleared in the process. Locating production areas enables companies to identify potential risks, engage with suppliers, and measure progress. Ideally, this would entail a level of transparency in which the specific boundaries of farms where oil palm fruit is harvested are identified. In reality, for most companies, tracing palm oil to source farms is complex, time-consuming, and costly.

However, in recent years, a growing number of companies have begun tracing their supply chains to the mill level. While not providing information as specific as farm boundaries, mill locations provide a valuable estimate of where the supply for a specific mill is coming from. This is because fruit from oil palm needs to be processed within one day of harvesting to ensure maximum productivity. Mills located near plantations ensure that fresh fruit bunches (FFBs) arrive at the mills soon after harvesting for processing. This reduces transportation costs from plantation to mill and ensures that FFBs arrive at mills with minimal spoilage and maximum quality standards.

Even traceability to the mill level is not a simple task due to the additional time and investment needed to track products throughout a company's complex supply chain. To achieve traceability to the mill level, companies, often partnering with consulting firms, research organizations, and civil society organizations, invest a great deal of attention and resources on collecting and verifying supplier mill information, such as location, mill name, and parent company. Collecting and verifying such information often requires companies and partners to set up preliminary individual agreements with suppliers before collecting traceability data separately for each supplier. Many companies have made significant progress in this endeavor, responding to the strong demand from civil society groups and other stakeholders for a greater level of transparency around supply chain information. Several major palm oil buyers have recently gone a step further to publish databases of their supplying mill locations publicly.

As a result, an increasing number of mill databases have been developed by different parties using different methods and published in different locations. However, much of the information in these mill lists remains inconsistent due to the disparate approaches taken by each party. Frequently, the location of a mill and/or its identifying characteristics (such as name and parent company) are not collected in a common format, and there are often varying degrees of accuracy across mill databases. Moreover, many mill lists include overlapping information (both within an individual list and between lists) and the location and characteristics associated with a particular mill area are often inconsistent between sources. For example, three lists may have slightly different information for a single mill. List one may show the mill at a slightly different location as compared with list two, while list three could show a different name for the same location as list two.

The inaccuracies and inconsistencies cause a number of challenges. From companies' perspectives, these inconsistencies cause difficulties in terms of internal management and business-to-business reporting. For example, a palm oil buyer seeking to trace their palm products back to origin requests the three mill lists referenced in the example above from three of their direct suppliers. These suppliers all source from the same mill but submitted slightly different information regarding that mill via their respective mill lists. Because of this conflicting data, the buyer may mistakenly assume these are three unique mill points. When the buyer wishes to make public their list of palm oil mills and share lists with other companies or stakeholders, two additional erroneous mills will have been created, leading to the distribution of incorrect data.

If this problem occurs with a larger set of mills and these lists are further disseminated, it decreases the accuracy and reliability of such lists in the public domain. This affects buyers' abilities to identify issues and track the progress of the supplying mills in an efficient way, and undermines the ultimate goal of traceability—to create a credible and transparent sector. Now, imagine a report from a campaign organization comes in about a mill contributing to illegal deforestation. Even though the buyer has mill lists from all their suppliers, this buyer would not be able to confidently say whether that mill is part of their supply chain.

With these challenges and inconsistencies in mind, the principal goal of the Universal Mill List (UML) is to aid in the ongoing collection, verification, and communication of palm oil mills worldwide. This technical note outlines clear processes for how newly published mill lists can be integrated into the UML and how the UML is managed, updated, and published for the benefit of all stakeholders in the palm oil sector. Importantly, the maintained UML will be a global database of mills, each with a unique ID, allowing users to easily identify, manage, and share mills in the public domain. Above all, we hope that the UML

will facilitate the sharing and publication of the locations and names of palm oil mills, thereby increasing the transparency of the sector as a whole.

METHODOLOGY

Creation of the UML and Updates

The UML is created and updated using a consistent process outlined at a high level in Figure 1. Specifically, the process to create and update the UML consists of the following broad steps:

1. Collect the raw list of mills to be considered for the UML and remove any in-list duplicates.
2. If mills in the list are not already in the UML, verify these new mills using the verification protocol in this document.
3. Conduct nearby duplicate analysis.
4. Clean attributes.
5. Assign unique IDs.
6. Update UML: Add new mills and perform necessary data corrections to existing UML mills.

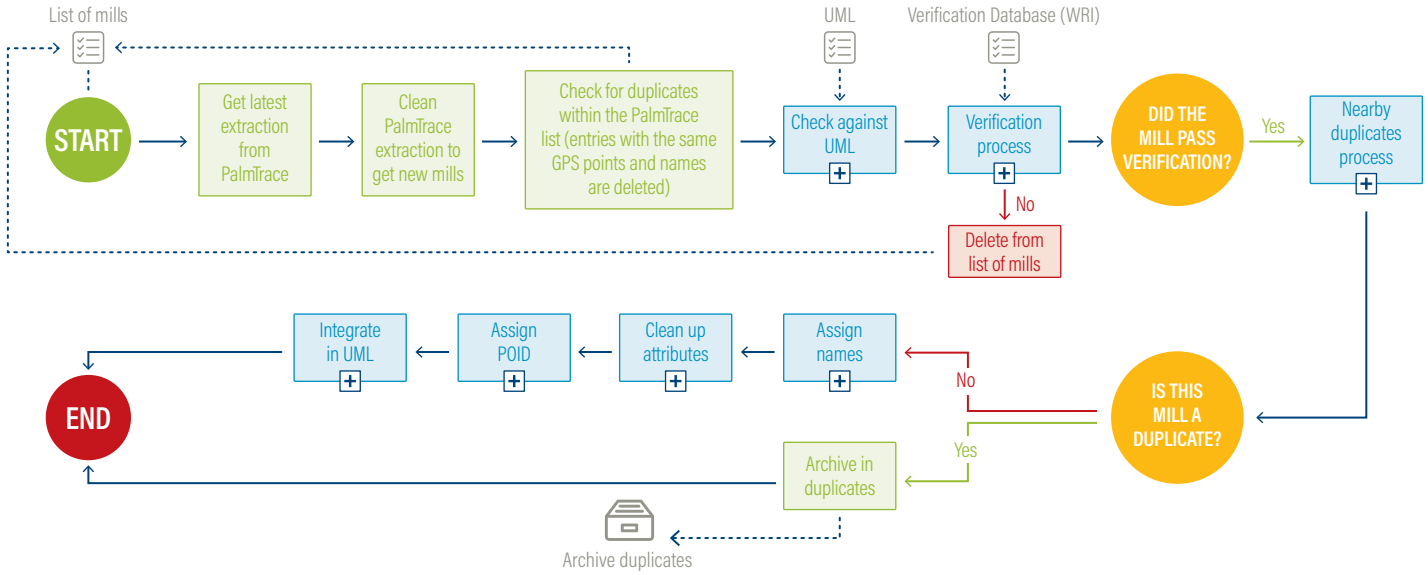
1. Collection of New Mills

To be considered for inclusion in the UML, submitted mills must have coordinates and a name. Mills that meet these criteria are collated into one spreadsheet. The coordinates of the mills on this list are cross-checked against mills on the UML. If a mill is not already in the UML, it enters the verification process. This dataset integrates publicly available mill information, including for mills that are certified through the Roundtable on Sustainable Palm Oil (RSPO), a sustainable palm oil certifying body, as well as those privately submitted by various companies.

2. The Verification Process

For a mill to be added to the UML, it must be verified using the protocols shown in Figure 2. Verification focuses heavily on location-based data because these data are verifiable by any person for any list of mills. Throughout the verification process, there are three databases used to keep track of mill verification status: the verification database, the duplicate database, and the UML. The verification database includes every mill that is submitted to be verified and includes all the information shown in Table 1. The duplicate database contains

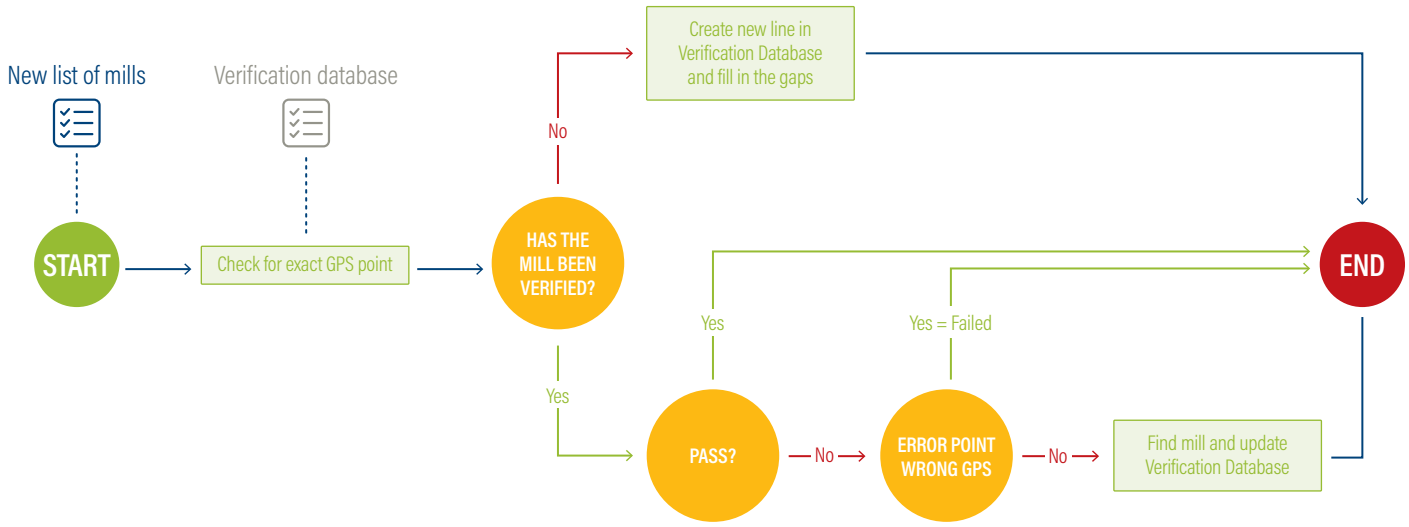
Figure 1 | **Graphical Representation of the Overarching Process to Update the UML with New Mills**



Note: POID stands for Palm Oil ID; these IDs are carried over from those given in Rainforest Alliance's PalmTrace platform.

Source: WRI authors.

Figure 2 | **Graphical Representation of the Subprocess for Verifying New Mills**



Source: WRI authors.

a list of mills that have previously passed verification but have been compared with the UML and were found to be nearby duplicates. The third database, the UML, contains all mills that have passed verification and does not include any nearby or exact GPS duplicates. The use of these databases will be explained in further detail in the following section.

2.a Coordinate/location verification

The first step in this process is to determine if a mill's GPS point actually falls on land, as many GPS points are locations in the ocean. After this, the mill's GPS point is examined in a high-resolution-imagery platform (resolution of 5 meter [m] or higher) such as DigitalGlobe, Planet, Google Maps, or Bing! Maps to determine if the GPS point is a mill. The mill's GPS point is considered accurate if there is a mill visible via imagery within 1 kilometer (km). To help determine the confidence level of each mill, detailed observations of infrastructure and features surrounding the GPS point that are known to be associated with palm oil mills are recorded as shown in Table 1. If there is no mill in the available image, and no recent images within the last six months, then that mill is marked as such in the Verification Database.

2.b Common mill data issues

There are many common problems with incoming mill data, the most common of which include the following:

- Inaccurate coordinates based on satellite imagery
  - Point falls in the middle of a forest/plantation
  - Point falls in the middle of a city
  - Point falls near mill but not on it
- No clear or recent imagery
  - Image quality is poor
  - There are no images available within the past two years
- Visible infrastructure is difficult to identify as a mill
  - Schools, industrial areas, and housing can be confused with mills
  - Point does not include key infrastructure such as silos or settling ponds
  - Interpreter knowledge or map services (like Google or Bing) give clear indications that the infrastructure in the imagery is not a mill

Table 1 | **Mill Verification Guidelines**

FEATURE	DESCRIPTION	OPTIONS
Oil Palm Plantation	Are there clear industrial oil palm rows near the mill, or plots of small-scale palm?	Yes/No
Mill-Like Infrastructure	Is there mill-like infrastructure? This includes palm reception areas and oil clarification sectors (large warehouse-like buildings), storage tanks (silo-like), and nearby small offices.	Yes/No
Other Infrastructure	Are there other buildings around that aren't mill infrastructure? This includes houses, villages, and any significant buildings that aren't related to a mill. (Note, most mills have some small housing for workers on-site; these aren't included in necessary mill infrastructure). Generally, consider infrastructure within 0.5 km.	Yes/No
Settling Pond	Is there a settling pond?	Yes/No
River	Is there a river, sea, large lake, or ocean? The body of water should be within about 1 km to be considered if there are no settling ponds.	Yes/No
Roads	Are there roads? All mills must be connected to a road.	Yes/No
Imagery Month	In what month was the image taken?	Enter a number from 1 to 12
Imagery Year	In what month was the image taken?	Enter the year of most current clear imagery
Image Resolution	How clear are the images?	Choose: Poor (large pixels and hard-to-make-out details) Good (clear enough to identify oil palm grid cells and ponds) Very good (can count palm trees and see fine details) See Appendix 1 for examples
Other Notes	Add notes to clarify points if needed. If failed, list why the mill failed.[a]	Text
Pass/Fail	Does this pass as a mill?	Choose: Pass/Fail
Confidence	The confidence that the coordinates refer to a mill point.	Choose 1 – Fully Verified 2 – High Confidence 3 – Low Confidence 4 – Context Fail 5 – Error Point Fail

Note: [a] The following are examples of point failure logic: Point falls in plantation/forest, no mill infrastructure; Mill is 6 km away; Point falls on what looks like a shipping port/storage area; Point labeled as a refinery in Google Maps.

Source: WRI authors.

Table 2 | **Guidelines for Assigning Confidence Levels**

MILL PASSES
1. **Fully verified.** The GPS point clearly represents a mill: ▪ It has mill infrastructure, has settling pond(s)/water, is on a plantation, and is connected to a road ▪ GPS point falls within the property of the mill or ponds (area between mill infrastructure and road) Imagery is very clear or good.
2. **High confidence.** The GPS point *almost certainly* represents a mill: ▪ It has mill infrastructure, has settling pond(s)/water, is in a plantation, and is connected to a road ▪ Imagery is very clear or good Not fully verified because of one or more of the following: ▪ The point is slightly off (<1 km) ▪ The mill infrastructure is slightly different than normal (e.g., missing storage silos, parts under construction) ▪ Very clearly a mill but missing a pond or a plantation
3**.** Low confidence**.** The GPS point ***probably*** falls on a mill: ▪ It has mill infrastructure and possibly settling ponds/water and plantation Not fully verified because of one or more of the following: ▪ Far from plantations but looks like a mill (e.g., the GPS point falls in a city) ▪ Image quality is poor but still looks like a mill (usually can see ponds) ▪ Clear mill-like infrastructure but no ponds or plantation ▪ Infrastructure is hard to determine but has palm plantations (and possibly ponds) ▪ Mill infrastructure is smaller than normal
MILL FAILS
4. **Context fail.** The mill failed because of one or more of the following: ▪ Bad/not recent imagery ▪ "Poor" imagery rating ▪ Recent is within two years ▪ The mill infrastructure is questionable (missing some key component) and there are no plantations or ponds
5. **Error point fail.** The GPS point very clearly does not fall on a mill: ▪ Point is not a viable GPS point (0.000000,0.000000) ▪ Mill is in the ocean, on a highway, or in another impossible location ▪ Very clear/good imagery shows no mill infrastructure/roads (e.g., middle of a forest or plantation) ▪ Point is referring to another building type (e.g., school, energy plant, office of company)

Source: WRI authors.

Each GPS point receives a level of confidence during the verification process. The rules for assigning confidence levels to the candidate mills are listed in Table 2, with an example checklist in Table 3.

This process may result in failing mills that are not standard looking but are in fact mills. This is more common in South America and Africa. In these cases, if a mill is hard to determine as pass or fail based on imagery alone, the verifier can use context clues. For instance, an RSPO-certified mill is more likely to have an accurate GPS point because the information needs to be verified by a certification body before it can be RSPO certified. The RSPO status of the mill is a context clue in this case. Google and other map services may also provide information on what is located at that point and Google Street View may offer a clear image of a sign. These clues will help fail or pass a mill. Large schools and other energy plants and processing facilities often look like mills but are clearly labeled as not mills on these other sites. At the end of this process, all mills will "pass" or "fail" verification.

- **Passed Mills:** Move to the next step of verification.
- **Failed Mills:** Returned to data provider in an attempt to get more accurate data.

A record of all passed and failed mills is kept for reference.

3. Duplicate Analysis

Once candidate mills have been verified, the next step is to remove duplicates, a process that can be time-consuming. There are a few ways mills can be considered duplicates:

- Same coordinates and same or similar names
- Same coordinates and different names
- Nearby coordinates and same or similar names
- Nearby coordinates and different names

Figure 3 shows the workflow for removing duplicates from the list of new mills to be verified.

3.a Exact GPS duplicates

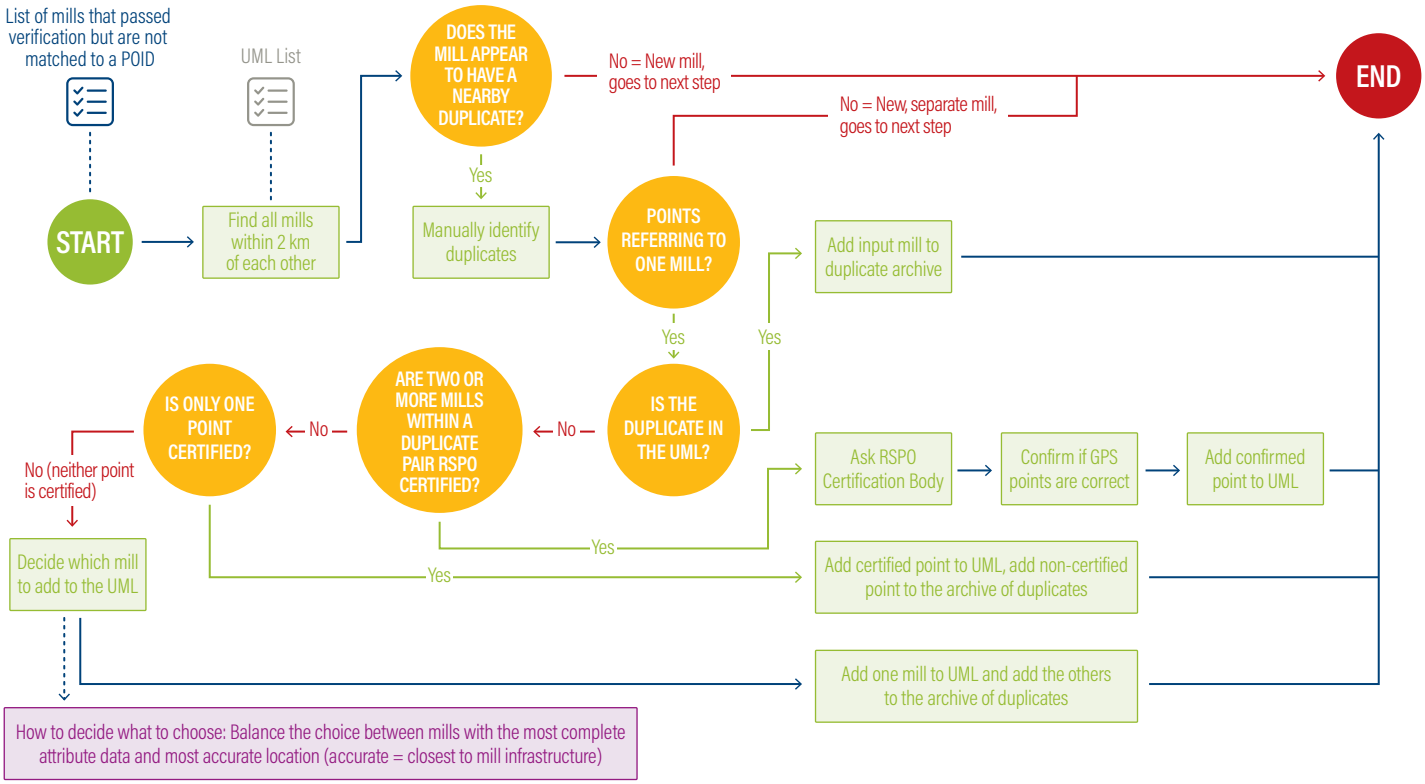
All GPS point duplicates with the same or similar names to any existing mills in the UML are not added because there cannot be two mills directly on top of each other, and including the same mill twice affects reporting for certification. If one point has two associated mill names, and one of the mill names is registered as RSPO certified and the other mill name is not, then the name of the RSPO-certified mill takes precedence and is added to the UML. If none of the mill names correspond with an RSPO-certified mill, then the name associated with the most accurate GPS point will be kept as the initial name and the second name will be kept as an alternative mill name in the UML.

Table 3 | **Checklist of Scenario Guidelines for Assigning Confidence Levels to GPS Points in the Verification Database, as a Result of Combining the Verification Criteria**

MILL-LIKE INFRASTRUCTURE	PLANTATION	SETTLING PONDS/WATER	IMAGE QUALITY	CONFIDENCE ASSIGNMENT
Yes	Yes	Yes	Very clear/good	1 - Fully verified
Yes	Yes	Yes	Poor	2 - High confidence
Yes	Yes	No	Very clear/good	2 - High confidence
Yes	Yes	No	Poor	3 - Low confidence
Yes	No	Yes	Very clear/good	2 - High confidence
Yes	No	Yes	Poor	3 - Low confidence
Yes	No	No	Very clear/good	3 - Low confidence
Yes	No	No	Poor	4 - Context fail
No	No	No	Very clear/good	5 - Error point fail

Source: WRI authors.

Figure 3 | **Graphical Representation of Workflow to Remove Duplicate GPS Points from the List of New Mills to Be Added to the UML**



Source: WRI authors.

3.b Optional nearby analysis

The mills are then optionally checked against another database of mills containing known nearby duplicates to mills in the UML. This reduces the number of mills that need to be analyzed during the nearby GPS duplicate analysis.

3.c Removing nearby GPS duplicates

To remove nearby GPS duplicates, GIS (geographic information system) is used to identify mills that fall within a 1 km radius of other mills. This has been determined to be the distance apart that any two points referring to the same mill will likely be from each other or any mill already in the UML.[1] After generating a list of matching points using the Near Analysis tool in ArcMap, each set of points is visually inspected to determine if the nearby points are separate mills or refer to the same mill.

For a set of nearby GPS points with the same name, if one of the GPS points has an exact match with an RSPO-certified mill, then that point is added to the UML.

4. Attribute Data

4.a Name verification

Verifying mill names is the most difficult of the verification steps. Mill names are important for traceability and taking action at the ground level. To verify names, the records of all the new mills are compared against the existing UML. If a new mill has the same GPS point but a different name, we highlight this mill and determine which name is correct through additional research (i.e., verifying with other traceability organizations or using Google Street View to see the name of the mill). Alternate names are stored in the UML attributes.

4.b Duplicate names

Often, two verified mills will have the same name but two GPS locations. In this case, we keep both mills. Mills with identical names cannot be registered in RSPO PalmTrace, the traceability platform that UTZ Certified provides to support RSPO's certification processes. Therefore, if one of the mills does not have a valid alternative name, the abbreviation "POM"—which stands for palm oil mill—will be added at the end of the name so that both mills can be registered, each with a unique ID. Figure 4 illustrates the workflow of the subprocess to assign names. In the rare case where more than two mills have the same name, Rainforest Alliance will investigate the given mills further to determine the most accurate names for them and ensure that each is given a unique name.

4.c Cleaning attribute data

The last step of the verification process is to clean the mill attributes. The UML uses 15 attributes. For most attributes, the information is provided by the source of the data (e.g., RSPO, company lists) but a few attributes are added by the UML creators. Their names, descriptions, and sources of information are listed in Table 4.

4.d Attributes determined by UML creators

GPS: The GPS point is generated by combining the latitude and longitude.

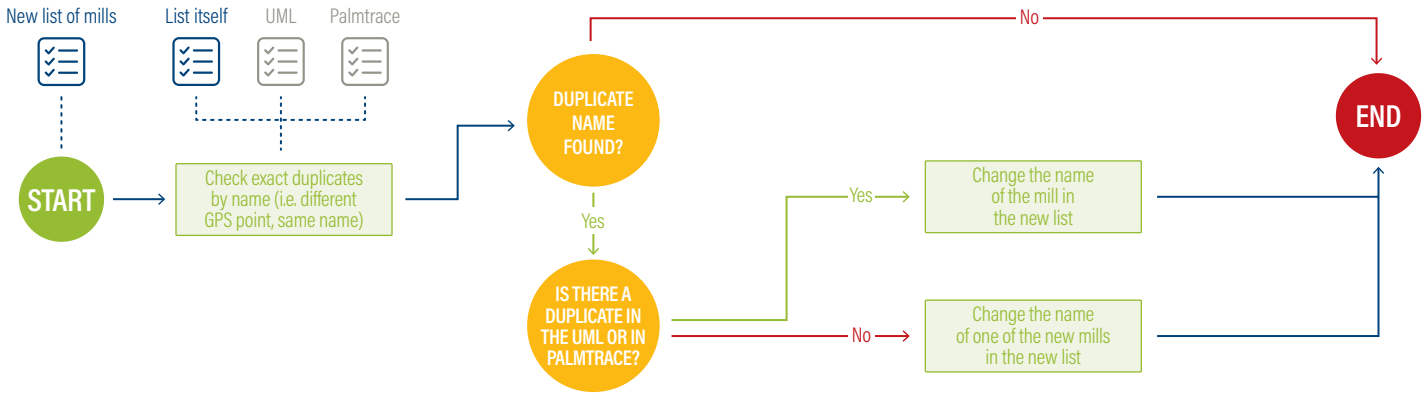
Administrative location attributes: The International Organization for Standardization code, country, province, and district are all created according to the location of the mill. The administrative areas data come from the latest GADM dataset, version 3.6, for the mill list published with this technical note. This is done by the UML creators to standardize the data.

UML ID: The unique UML ID for each mill in the list.

RSPO status: This status ("RSPO certified" or "Not RSPO certified") references the certification status of the mill, against the RSPO standard, at a cutoff date established by the creators of the UML, considering the publication date (i.e., an arbitrary date close to the publication date each time the UML is updated). As the certification status can change at any moment due to different factors (e.g., the one-year license expires before a new license has been requested in the PalmTrace system, or the mill is decertified by the certification body), the UML displays only the status at the moment of the cutoff date. For this reason, the following disclaimer is published together with the list in a manner that it is visible and clear to the users of the UML:

"The disclosed certification status was correct on [date]. As this status is subject to change, we recommend checking the latest certification status on RSPO's website at https://www.rspo.org/certification/certified-growers-search."

Figure 4 | **Graphical Representation of the Subprocess to Assign Mill Names**



Source: WRI authors.

Table 4 | **Mill Attributes in the Universal Mill List**

ATTRIBUTE	DESCRIPTION	REQUIREMENTS	ATTRIBUTE FROM SUBMISSION SOURCE OR UML CREATOR?
Group Name	Name of the group the mill company belongs to for high-level traceability	Text in title case (abbreviations have no periods)	Original list submission source or tax documents
Parent Company	Name of the parent company for mid-level traceability	Text in title case (abbreviations have no periods)	Original list submission source or tax documents
Mill Name	Name of the mill for ground-level traceability	Text in title case (abbreviations have no periods)	Original list submission source or tax documents
RSPO Status	The certification status of the mill for reporting purposes	Options: ▪ Not RSPO certified ▪ RSPO certified	UML creators
RSPO Type	If certified, the certification type of the mill (i.e., identity preserved and mass balance)	Options if noncertified: ▪ "" (field is left blank) Options if certified: ▪ RSPO certified ▪ RSPO certified, Identity Preserved (IP) ▪ RSPO certified, Mass Balance (MB) ▪ RSPO certified, MB & IP	UML creators
Date	Date that the certification status of the mill was last updated (registration)	Date: DD/MM/YYYY	UML creators
Latitude	Latitude of mill point	Number, 6 decimals, -90 to +90, decimal degrees	Original list submission source
Longitude	Longitude of mill point	Number, 6 decimals, -180 to +180, decimal degrees	Original list submission source
GPS	Combination of latitude/longitude	Text, "latitude, longitude"	Original list submission source
ISO	International Organization for Standardization (ISO) code of the country the mill is in	Text, 3 letter code	UML creators
Country	The country the mill is in (based on GPS and GADM3.6[a])	Text	UML creators
Province	The province the mill is in (based on GPS and GADM3.6)	Text	UML creators
District	The district the mill is in (based on GPS and GADM3.6)	Text	UML creators
Alternative Mill Name	Alternative name for mill	Text	Original list submission source
UML ID	UML ID, starts with POID[b]	Text	UML creator

Notes: [a] GADM3.6 is a dataset that contains the administrative areas for all countries and can be downloaded here: https://gadm.org/download_world.html. [b] POID stands for Palm Oil ID; these IDs are carried over from those given in Rainforest Alliance's PalmTrace platform.

Source: WRI authors.

5. Assigning UML IDs to Mills

Once a mill has passed verification, it must be assigned a UML ID to become part of the UML. The process for assigning an ID is outlined in Figure 5.

5.a Mills that exist in PalmTrace

For mills that exist in RSPO PalmTrace, the unique ID associated with the account is assigned to the mill.

5.b Mills that do not exist in PalmTrace

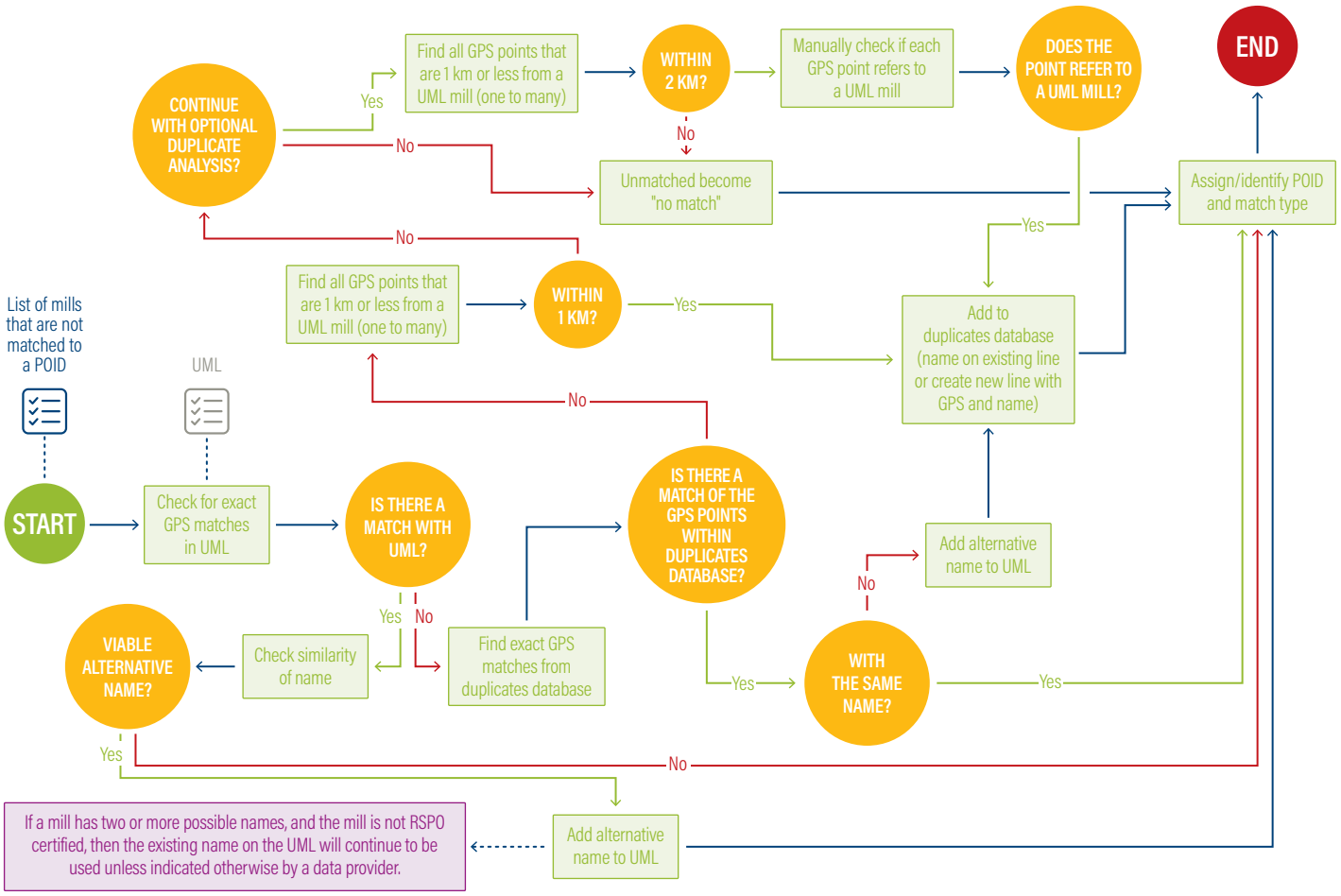
For mills that do not exist in RSPO PalmTrace, a new UML ID is created by Rainforest Alliance on RSPO PalmTrace that is assigned to the mill.

6. Updating the UML

The UML is updated roughly every six months. All updates of any type are completed during these biannual update periods. The cutoff date for new and updated data is three months prior to the release date. This cutoff date may be shorter, depending on the time availability of all parties. There are two types of updates: new mills and data corrections.

- **New mills** are those that have passed verification and may be added to the UML. These mills do not have a UML ID, so a new one is created and assigned to them.

Figure 5 | **Graphical Representation of the Subprocess to Assign UML IDs to Mills**



Note: POID stands for Palm Oil ID; these IDs are carried over from those given in Rainforest Alliance's PalmTrace platform.

Source: WRI authors.

- **Data corrections**: Data corrections occur when attributes of a mill already in the UML are altered. All these mills will *already have an assigned UML ID.* Any type of data can be changed *except* the GPS point. If there is a compelling reason to alter a GPS point, a new UML ID must be assigned, and the old GPS point and UML ID are removed.

Additionally, other organizations that wish to contribute their own collections of company/supplier lists to the UML may provide their own lists of candidate mills and attribute information to be considered for the UML. Their mills will go through the verification process as described above. If it is found that an organization has more accurate attribute information about a mill in the UML, as gathered from tax documents and other certifications, then the existing mill's attributes will be updated. These organizations are given the opportunity to review the verification results and give feedback on the integration of their mills into the UML before the consequent update is published. These organizations will then also be included in the dataset citation.

LIMITATIONS

Limitations of this methodology revolve around the attribute data and the quality of data submitted by various private companies. Many companies submit multiple attributes for the same mill location, which makes it difficult to know which data are correct. Furthermore, up-to-date images that are clear of clouds and are high-enough resolution to discern mill infrastructure are not always available at the time of verification, which can delay the process. Lastly, emerging mills in places like West Africa and Central and South America do not always appear the same as standard mills in Indonesia and Malaysia. In addition, in South America, beef slaughterhouses can sometimes be mistaken as palm oil mills.

RESULTS

The palm oil mill verification process results in a database of accurate palm oil mill locations and attribute information—making it the first global, multiorganizational, standardized list of palm oil mills. This database will make it easier to address issues of supply chain management, containing over 1,800 verified mill locations.

The Universal Mill List is being used for multiple research projects at World Resources Institute. The list is being used as part of an analysis to determine emerging places to watch for deforestation due to oil palm plantation expansion. A service area analysis for each mill is being used as an input into the overall analysis because a large portion of plantations are within a 50 km road network of mills due to the time sensitivity of oil palm processing. The service area created from the list is also being used in a palm oil carbon emissions analysis. Lastly, the mill database is being used to calculate baseline mill deforestation risk levels to compare individual company mills through the Global Forest Watch Pro Palm Risk Tool.

The Universal Mill List will also serve as a verified and accurate mill database within RSPO PalmTrace. In particular, the Universal Mill List will support the traceability of both certified and conventional palm material and allow both RSPO PalmTrace users and other stakeholders to easily identify and share mill sources. The Universal Mill List will also be used to support companies in the palm sector to reach their traceability commitments by facilitating the traceability of conventional palm sources to the mill level.

APPENDIX I. EXAMPLES OF MILL VERIFICATIONS

Example 1:

This image shows an example of a GPS point that clearly falls on a mill. There are features that can be clearly identified as mill infrastructure, such as settling ponds, silos, and a warehouse. This point also falls within a plantation and has a road, all of which are ideal for mill locations. This mill received a confidence level of 1 - Fully Verified.

Example 2:

This image shows an example of a GPS point that also clearly falls on a mill, though the image is panchromatic and not true color. There are features that can be clearly identified as mill infrastructure, such as settling ponds, silos, and a warehouse. This point also falls within a plantation and has a road. This mill received a confidence level of 1 - Fully Verified.

Example 3:

This image shows a GPS point that likely falls on a mill, but the image quality is not very clear due to cloud cover. There are features that can be clearly identified as mill infrastructure, such as silos and a building that could be a warehouse. This point also falls within a plantation and has a road. Although there are no visible settling ponds, the point is on a river. This mill received a confidence level of 3 - Low Confidence.

Example 4:

This image shows a GPS point that likely, but not certainly, falls on a mill due to its location in a larger industrial area with many other buildings. There are features that can be clearly identified as mill infrastructure, such as silos and warehouses, but there are no identifiable settling ponds. This point also falls within an industrial area surrounded by a plantation and has many roads so it could also be a refinery. This mill received a confidence level of 3 - Low Confidence.

Example 5:

This image shows a GPS point that does not fall on a mill. The actual GPS point fell within a road, and the surrounding buildings are not representative of mill infrastructure. The point was not located close to a plantation, and there were no indicators of mill activity. This mill did not pass and received a confidence level of 5 - Error Point Fail.

Example 6:

This image shows a GPS point that does not fall on a mill. The actual GPS point fell within a plantation. This image was taken in May 2018, and there are no signs of mill construction. This mill did not pass and received a confidence level of 5 - Error Point Fail.

Example 7:

This image shows two mills next to each other. The point falls on the mill to the bottom left; the top-right mill already exists in our database. Since the second mill has separate, distinguishable settling ponds, silos, and warehouses, it passed with a confidence level of 1 - Fully Verified.

Example 8:

This image shows a mill that was verified with Planet imagery. You can see the settling ponds and some large buildings, as well as the road infrastructure through the plantations. This mill passed with a confidence level of 2 – High Confidence.

ENDNOTES

1. This was determined by visually examining 300 points that were within 2 km of mills already in the UML, where 98 percent of new points near existing UML mills fell within 850 meters. During verification using high-resolution satellite imagery, any point within 1 km of the mill infrastructure can "pass" and be considered a mill.

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World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

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Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

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We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

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We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

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